CLAIMS

What we claim and desire to protect by Letters Patent is:

1. A multilevel mold for imprint lithography that contains a relief image of a dual damascene structure.

2. A method for producing a multilevel mold that contains the relief image of a dual-damascene structure or the negative relief image of a dual-damascene structure.

3. The method as defined in Claim 2 comprising:
   a. Coating a mold substrate with a photoresist;
   b. Patterning said photoresist with a pattern;
   c. Exposing said photoresist and pattern, and developing said pattern in said photoresist;
   d. Transferring said pattern in said photoresist into an upper surface of a mold substrate;
   e. Coating said upper surface of said mold substrate with a planarizing layer to form a planarized stack;
   f. Coating said planarized stack with a photoresist;
   g. Exposing said photoresist and developing the pattern in said photoresist;
   h. Transferring said pattern into said mold substrate.

4. The method as defined in Claim 3 wherein an etchmask is applied between said mold substrate and said photoresist, and where said resist and/or etch mask is used for a pattern transfer into said mold.

5. The method as defined in Claim 2 comprising:
   a. Coating a mold substrate with a multilayer hardmask stack etch mask;
   b. Coating said multilayer hardmask stack etch mask with a photoresist;
   c. Exposing said photoresist and developing the pattern in said photoresist;
   d. Transferring the pattern in the photoresist into a top layer of said multilayer hardmask stack etch mask;
   e. Coating the resultant mold substrate article with a planarizing layer to form a planarized stack;
   f. Coating said planarized stack with a photoresist;
   g. Exposing said photoresist and developing a pattern in said photoresist;
   h. Transferring said pattern into the etch mask layers;
   i. Transferring the multilevel pattern in the etch masks into the mold substrate.

6. The method as defined in Claim 5 wherein said multilayer hard mask stack is a trilayer hardmask stack.

7. The method as defined in Claim 6 wherein said trilayer hardmask stack has a bottom layer, a middle layer and a top layer.

8. The method as defined in Claim 7 wherein said bottom hardmask layer is an etchstop layer, said middle hardmask layer is used to print negative line level patterns and negative via level patterns and said top hardmask layer is used to pattern negative via level pattern, wherein the line level pattern and the via level pattern are both negatives of the pattern such that the resulting relief in the mold is the negative of the desired dual damascene features.

9. The method defined in Claim 3, wherein said line level pattern is exposed and transferred into said mold substrate prior to exposing the via level pattern and transferring the via level pattern into said mold substrate.

10. The method defined in Claim 3, wherein said line level pattern and via level pattern are exposed and transferred into the mold substrate prior to exposing said line level pattern and transferring said line level pattern into said mold substrate.

11. The method defined in Claim 4, wherein said line level pattern is exposed and transferred into said hardmask prior to exposing the via level pattern and transferring the via level pattern into said hardmask.

12. The method defined in Claim 4, wherein said via level pattern is exposed and transferred into said hardmask prior to exposing said line level pattern and transferring said line level pattern into said hardmask.

13. The multilevel mold defined in Claim 1, wherein said mold substrate is a material selected from the group consisting of quartz, silicon, pyrex, Indium Tin Oxide, GaAs and InP.

14. A multilevel dual damascene structure comprising a curable material on a substrate, said multilevel dual damascene structure being formed and shaped utilizing a multilevel mold structure and a single imprint lithography process as defined in Claim 3.

15. A multilevel dual damascene structure comprising a curable material on a substrate, said multilevel dual damascene structure being formed and shaped utilizing a multilevel mold structure and a single imprint lithography process as defined in Claim 4.

16. The multilevel mold structure structure defined in Claim 14 wherein said substrate is formed from electronic means selected from the group consisting of a microelectric chip, a chip carrier, a bio-chip, a microfluidic device and an optoelectronic chip.

17. The multilevel structure defined in Claim 14 wherein said curable material is cured partially or completely during the imprint step using heat, light, pressure, or combinations thereof.

18. The multilevel structure defined in Claim 17 wherein said curable material functions as an interlayer dielectric.

19. The multilevel structure defined in Claim 15 wherein said curable material acts as a etch mask for an underlaying material.

20. The multilevel structure defined in Claim 18 wherein said curable material is formulated with a curing process initiator selected from the group consisting of a free radical generator, a photoacid generator, a thermal free radical generator and a thermal acid generator.

21. The multilevel structure defined in Claim 14 wherein said curable material is selected from the group consisting of photo free radical generators, thermal free radical generators, photo acid generators and thermal acid generators.

22. The multilevel structure defined in Claim 14 wherein said curable material is formulated using an organic polymeric resin selected from the group consisting of polymethylmethacrylate, polyacrylates, polyepoxides, functionalized dimethylsiloxanes, alkylsilanes, functionalized methsilsesquioxanes, hydrosilsesquioxanes, polyurethanes, polycyanoacrylates, polystyrene polyvinyls, polyvinylethers, ketene acetals, cyclohexyl epoxides, a polymeric network crosslinked by a diene-dieneophile reaction comprising a Diels-Alder reaction and polyimide.

23. The multilevel structure defined in Claim 15 wherein said curable material is formulated using an organosilicate resin selected from the group consisting of polyhedral silsesquioxanes, silsesquioxanes, dimethylsiloxanes, polycarbosilanes.

24. The multilevel structure defined in Claim 14 wherein said curable material is formulated using conductive polymers selected from the groups consisting of poly(thiophene) and polyanaline.

25. The multilevel structure defined in Claim 14 wherein said curable material contains a multifunctional monomer or oligmer that serves as a crosslinking agent.

26. The multilevel structure defined in Claim 14 wherein said curable material contains low molecular weight materials selected from the group consisting of methyl acrylate, methyl methacrylate, epoxides, vinyls, silyl vinyl ethers, ketenes, or functionalized versions of polyhedral silsesquioxanes, silsesquioxanes, dimethylsiloxanes, polycarbosilanes, and combinations thereof.

27. The multilevel structure defined in Claim 14 wherein said curable material contains coupling agents designed to form covalent bonds between the substrate and the cured material, said coupling agents selected from the group consisting of acrylate functionalized silanes, 3-acryloxypropyltrimethoxysilane, alkoxysilanes functionalized methacrylates, polyacrylates, polyepoxides, functionalized dimethylsiloxanes, alkylsilanes, functionalized methsilsesquioxanes, hydrosilsesquioxanes, polyurethanes, polycyanoacrylates, polystyrene polyvinyls, polyvinylethers, ketene acetals, a polymeric network crosslinked by a diene-dieneophile reaction comprising a Diels-Alder reaction and polyimide.

28. The multilevel structure defined in Claim 14 wherein said curable imprint material contains release agents designed to minimize adhesion to a multilevel mold or template, said release agents being selected from the group consisting of tridecafluoro acrylate, functionalized methacrylates, acrylates, epoxides, cyclohexylepoxides, functionalized dimethylsiloxanes, alkylsilanes, functionalized methsilsesquioxanes, hydrosilsesquioxanes, polyurethanes, polycyanoacrylates, polystyrene polyvinyls, polyvinylethers, ketene acetals, a polymeric network crosslinked by a diene-dieneophile reaction comprising a Diels-Alder reaction.

29. The multilevel structure defined in Claim 14 wherein said curable material contains resin(s), monomer(s), coupling/adhesion agent(s), release agent(s), and a crosslinking agent selected from the group consisting of bis functional methacrylates, acrylates, epoxides, functionalized dimethylsiloxanes, alkylsilanes, functionalized methsilsesquioxanes, hydrosilsesquioxanes, polyurethanes, polycyanoacrylates, polystyrene polyvinyls, polyvinylethers, ketene acetals,a polymeric network crosslinked by a diene-dieneophile reaction comprising a Diels-Alder reaction.

30. The multilevel structure according to Claim 14 which contains selectively decomposable and removable components in order to generate a porous structure said components forming a material being a thermally labil material that thermally degrades above 200°C selectively to resin, said material being selected from the group consisting of polymethylmethacrylate, polystyrene and polypropylene glycol.

31. The multilevel structure according to Claim 14 wherein said dual damascene structure contains one line level pattern and one via level pattern where said via level connects two vertically separated line levels and said line level consists of wires traversing said substrate.

32. A system comprising a plurality of elements functioning in combination to fabricate a dual damascene structure using the method defined in Claim 2.

33. The system defined in Claim 32 which includes the following elements:

a. A substrate handling system
b. A substrate stage
c. A mold stage
d. An irradiation system
e. A mold-substrate orientation control system
f. A mold fixture
g. A substrate fixture
h. A curable material dispensing system
i. A nitrogen purge system.

34. The system defined in Claim 33 in which said mold fixture is designed to hold a multilevel mold and designed to imprint said mold into a curable material.

35. The system defined in Claim 33 in which actuation of said mold in a process of manufacturing a structure is performed using piezo element(s), pneumatic elements, hydraulic elements or electromagnetic actuation.

36. The system defined in Claim 33 in which said mold fixture and said substrate fixture comprise flexure elements that allow for orienting said mold to the substrate in a co-planar fashion.

37. The system defined in Claim 33 in which said mold stage and/or said substrate stage comprise a stage in which a substrate is allowed to translate relative to a fixed mold.

38. The system defined in Claim 33 contains a stage in which the mold is allowed to translate a series of lines relative to a fixed substrate.

39. The system defined in Claim 33 wherein in said mold-substrate orientation control system a distance between a mold and a substrate is monitored by capacitance, pneumatic pressure drop, spectral reflectometry, single beam or multiwavelength interferometry or a combination thereof.

40. The system defined in Claim 33 in which the distance between a mold and a reference surface, and a substrate and a reference surface is monitored by capacitance, pneumatic pressure drop, spectral reflectometry, single beam or multiwavelength interferometry or a combination thereof.

41. The system defined in Claim 33 which incorporates a curable material dispensing system.

42. The system defined in Claim 41 wherein said curable material deposition system dispenses microliter or smaller droplets.

43. The system defined in Claim 41 wherein said curable material deposition system dispenses said curable material in a defined pattern.

44. The system defined in Claim 42 in which said curable material deposition system dispenses said curable material in a continuous pattern such as a series of lines forming a "W" pattern.

45. The system defined in Claim 42 in which said curable material deposition system dispenses droplets in a discrete pattern in a series of individual droplets.

46. The system defined in Claim 33 which incorporates a photon-emitter component suitable as means for irradiating a surface selected from the group consisting of a UV lamp, a laser, a quartz heater and a radiative heater.

47. The system defined in Claim 33 wherein thermal heating is accomplished through the mold.

48. The system defined in Claim 33 wherein thermal heating is accomplished through the substrate.

49. The system defined in Claim 33 wherein irradiation is accomplished through the mold.

50. The system defined in Claim 33 wherein irradiation is accomplished through the substrate.

51. The mold defined in Claim 1 in which a surface of said mold is treated with a low surface energy component.

52. The mold defined in Claim 51 wherein said low surface energy component is a fluorinated self assembly monolayer comprising a fluorinated alkyl halosilane, fluorinated alkyl alkoxysilane, fluorinated alkyl acetoxy silane and tridecafluorooctyltrichlorosilane.

53. The mold defined in Claim 1 wherein alignment marks are incorporated into a structure of said mold, wherein said alignment marks comprise diffractive grating, moire fringe, chirped, verniers and box-in-box patterns.

54. The mold defined in Claim 1 wherein said mold comprises a plurality of materials and wherein one or more of said materials is patterned with alignment marks.

55. The mold defined in Claim 1 which incorporates recessed regions used to confine displaced material.

56. The mold defined in Claim 55 which incorporates recessed regions on the periphery of the imprint pattern.

57. The mold defined in Claim 56 which incorporates a recess region that is pre-measured in order to provide a reference surface for substrate-mold gap control.

58. The system defined in Claim 33 wherein orientation of said mold-substrate is automated and translation of the substrate and/or the mold is automated.

59. The method defined in Claim 14 in which said curable material is spincoated on said substrate prior to imprint thus enabling a uniform imprint.

60. The mold defined in Claim 1 which is a second-generation mold that is fabricated by embossing a master mold into a curable material that is coated on a second-generation mold.

61. The multilevel structure defined in Claim 14 wherein said curable material comprises crosslinking functionalities suitable for negative-tone photo chemistry.

62. The multilevel structure defined in Claim 10 wherein said curable material contains a photosensitive component.

63. The multilevel structure defined in Claim 23, wherein said functionalized material is sensitive to acid, base, heat, pressure, and/or light.

64. The multilevel structure according to Claim 30 wherein said thermally labil material is subjected to UV exposure to reduce or enhance said decomposition.